

*To Mr. Heaviside with the author's
respectful compliments*

ESSAY
ON THE
CAUSES
OF THE
DRY ROT
IN BUILDINGS.

ESSAY

ON

THE ART

Printed by S. GOSNELL,
Little Queen Street, Holborn.

E S S A Y
ON THE
CAUSES
OF THE
DRY ROT IN BUILDINGS;

CONTAINED IN
A SERIES OF LETTERS
ADDRESSED TO
GEORGE ERNEST JAMES WRIGHT, Esq.
INCLUDING
SOME OBSERVATIONS ON THE CURE OF THE
Dry Rot,

AND ON THE
ADMISSION OF AIR INTO THE PARTS OF BUILDINGS AFFECTED
BY THAT DISEASE.

By JOHN PAPWORTH, ARCHITECT.

Omnes magnâ mediocrique sapientiâ res huc vocat: quæ quisque optima potest uti dicat.
SALLUST.

London:

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N. A. B. & H.

CHURCH

OF THE HOLY TRINITY

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Little Queen Street, Holborn.

INTRODUCTION.

THE decay of timber termed the dry rot, is so universally lamented, that I trust the following Letters will not be wholly unacceptable to the public, particularly as an intimate knowledge of the disease has long been anxiously desired. The weighty vocations which have deservedly required the labours of professional men of distinguished talent, having occasioned a total neglect of this subject, the causes of the disease have so long remained in obscurity, that in consequence they are considered as mysterious; and the measures resorted to, under pretence or hope of cure, being really founded on no precise principles, the application is rendered inefficacious and uncertain. The following observations are submitted with a degree of confidence resulting more from the necessity of the inquiry, than from any credit that can possibly attach to this investigation.

The ravages of this disease are well known to every person conversant in building; and to those whose property is very extensive, the enormous amount of annual repairs exhibits a melancholy testimony of its devastative principle. These frequent and futile ex-

penditures have long demanded much serious attention ; the dry rot becoming almost universal ; for it is seen that buildings are daily infected by it, while those which are already decayed, cannot be expected to receive a radical and effective remedy ; the disease being altogether unknown, or, what perhaps is worse, mistaken.

The expense attendant on repeated endeavours to eradicate the disease, and for the restitution of the rotted parts, is not the only evil consequence of its destructive properties. The timbers, which are the bond to an edifice, are frequently destroyed by it, the walls become impaired by the continued insertion of new timbers, and the unequal pressure which some parts of the building are necessitated to sustain : thus the primitive adjustment of support and weight no longer exists ; in consequence, the solidity of the building is destroyed. Such injuries will, I doubt not, be sufficient to mark the dangerous nature of the disease, without adverting to the dreadful consequences to which the inhabitants may be subjected.

The opinion generally received has drawn a line of discrimination between the decay, accompanied by a vegetable spreading on the surface of the timber, and that which is effected by an animal existing within it, which decay is frequently denominated the worm in timber ; but as each is equally entitled to the dreaded appellation, they might more justly be distinguished as the animal and vegetable dry rot.

INTRODUCTION.

It will be perceived that the subsequent Letters contain an investigation of the causes of the latter only, as being the most common and destructive. A future period may, however, afford leisure for submitting some observations on the animal dry rot, and the origin of the *teredines*, *teneæ*, *thripes*, and *cerastes*, which are the causes of it.

By various experiments it is evident, that, in the vegetable dry rot, the weed or fungus is adequate to occasion the decomposition of timber by an absorption of the cohesive qualities; and that in some instances the decay is independent of every other cause: indeed, the warm and damp situations in which such fungusses originate, and the moisture which they afford to the spots they occupy, may be supposed to swell, and render fluid the softer parts, admitting a degree of fermentation under them, which must facilitate the decay by producing a complete decomposition in every part; and the fungus of itself is so well calculated to absorb and convey the fluid particles to the circumambient air, that the separated state of the wood must necessarily transpire.

Under this impression I have endeavoured to show, in the following Letters, the origin of the fungus, and the relation of it to the disease, with other causes of decomposition. Without one previous observation it may appear, that buildings would be more generally affected than we find they are: it is, however, necessary, that a variety of circumstances be combined to produce a matter suited

suited to the generation of the causes, and the support of them for the destruction of the timber which every situation does not afford.

From the nature of the disease, as hereafter described, I trust the various effects of the dry rot on stones, and the communication of it through other materials to the timber, will be conceived without difficulty; for, as such considerations are but secondary to the cause of the disease, and would only tend to enlarge the inquiry, every observation upon them is designedly omitted.

From the natural causes by which the dry rot is produced, I doubt not but it will be imagined that the means of cure will necessarily present themselves; and that they may also be administered with the utmost certainty of success. Convinced that much injury may be done to buildings by erroneous conclusions of this nature, and by speculations founded upon them, I feel it a duty to observe, that the cure of this disease is attended with considerable difficulty even after a correct acquaintance with the causes, as the application of suitable remedies must correspond with the different origin of the disease, and extend to every part of the building affected: and although the timber cannot be restored to its primitive state of soundness, the remedy must be equal to arrest the progress of the disease in every part, perfectly to eradicate the cause, and finally to prevent a future contamination.

6, *Bath Place, New Road,*
Fitzroy Square.

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LETTERS,

LETTERS

ON THE

DRY ROT IN BUILDINGS.

LETTER I.

CONTAINING PRELIMINARY OBSERVATIONS.

SIR,

WITH peculiar satisfaction I have the honour to address you on the causes of the dry rot in buildings. It is a subject I have long investigated; and, from the observations which have resulted in the course of continued practice and experiment, I shall endeavour to give a systematic arrangement, in order to facilitate that careful consideration which I anticipate you will bestow on the subsequent inquiries.

The indulgence, Sir, which I have invariably experienced from you in very important concerns, encourages me to rely on the further extension of it to these observations: they are such as have resulted from the most particular attention, and on which I place considerable reliance. If, on examination, they should have your approval, and

B

concurrence,

concurrence, I shall receive it as a flattering testimony of their propriety.

The dry rot in timber derives its name from the effect produced, and not from the cause: it is so called in opposition to the wet rot, which is properly denominated, as this exists only in damp situations: but although the dry rot is usually generated in moisture, in some cases it will flourish independent of extraneous humidity.

The fungus which is found attached to timber is a cause, and by some supposed to be the only cause, of the decomposition called the dry rot: and as I shall hereafter endeavour to show the relations of the fungus to this disease, I must beg leave to make some observations on the origin of them.

OF THE ORIGIN OF FUNGUSSES.

On the propagation of fungusSES naturalists have considerably differed, and even at this period have left the origin of moulds and other fungusSES undetermined. The spontaneous origin of them is an ancient hypothesis, which the moderns have not confuted: I therefore trust this inquiry will not appear presumptuous, for I submit the following observations to you, Sir, being anxious only, in this very extensive field of speculation, that united endeavours may attain truth.

In attempting an elucidation of the causes of the dry rot, it is necessary to consider the origin of the fungus which sometimes
occasions

occasions it, and indeed of fungusses in general, as all appear to be governed by the same natural laws; but this, as I have observed, has never been sufficiently accounted for; some naturalists having insisted upon their spontaneous production, while others maintain that they are produced by seed, which is taken up and supported in the air until a soil proper for its nourishment is presented, on which being deposited, it springs up of various appearances according to the principle of the seed and the nature of the recipient. I shall have occasion to show that fungusses are not unfrequently generated below the surface of the ground, in fibres attached to the roots of trees: similar productions also arise from various corrupt matters in the earth, equally remote from the external air. On examining apples in a decaying state, it appears that small pustules are formed within the skin, which separates as they increase in magnitude, and shortly discloses perfect fungusses. These phenomena appear to favour the opinion of the ancients, that fungusses are sometimes the transformation of certain properties of one vegetable into a complete vegetable of another genus, formed in the small vacuities of fermenting masses, which receive and retain the gas or vapour that necessarily arises in such substances. Vapour or gas having no positive levity, some have concluded that as the nature of the fugitive particles assimilates, they may cohere and form bodies, the principle of mouldiness and other fungusses.

In order to be more fully acquainted with the propagative principle, I examined some of the experiments made by the ingenious naturalist Spallanzani, who has taken much pains to ascertain the origin of mouldiness; but, notwithstanding the plausibility of his hypothesis, that the germs of mould are disseminated through the air by their volatility; that, from their capability to endure a very

extraordinary degree of heat without injury, they may contain the germinating principle for ages; and that the infinite multiplication of germs may be sufficient to impregnate the superficies of the whole creation; it does not, I presume, wholly invalidate the doctrine of spontaneous generation; as it appears that several phenomena of importance necessary to the establishment of that hypothesis are not yet accounted for.

In considering the experiments of Spallanzani on the origin of the plantulæ of mould, I imagined I saw a probability of ascertaining the fact. By these experiments he demonstrates, that, “ in a vessel
“ hermetically sealed, the seeds of mould will not germinate, notwithstanding vegetable substances do produce fungusses in that
“ situation.” Again he observes, that, “ by sowing on certain
“ substances the seeds of mould, the increase is double the quantity or thickness to that produced by a substance on which no
“ seeds have been distributed.” And again, “ from a vegetable
“ substance exposed in a glass receiver, there exhales a degree of
“ moisture which adheres to the inside of the receiver, forming a
“ pellucid aqueous veil; and the increase is so considerable as to
“ form large drops which run down the sides of the receiver in
“ streams, meandering among the moistened places. The same
“ quantity of mould is produced upon the stream as is produced
“ by the wet flowing from the dissolving vegetables.” On these premises may be presumed the following conclusions:

That if sown seeds do not germinate in the same situation where the vegetable corruption produces mould, the principle of vegetation is therefore not the same.

That.

That on the corrupting substance the sown seeds produce only an equal quantity of plantulæ with the natural principle; therefore the superficies of the one must possess as many natural germs as there are seeds sown upon the other.

That the natural germs, if they do exist in the pellucid veil upon the receiver, should be as evident to the magnifier as the number sown on the corrupting substance. Germs in the pellucid veil never having been evident to the best magnifier, it is a fair conclusion that none exist in it; and upon the whole it appears an inference, that the generative principle of the plantulæ of mould is not always dependant on the seeds deposited, but is sometimes produced spontaneously.

The accurate investigation of the naturalist on the foregoing experiments and conclusions, might go very far towards a more intimate acquaintance with the propagation of mould and other fungusses; an interesting and useful knowledge, and of considerable importance to the subject on which I have the honour to address you.

The propagative analogy which pervades vegetable life is possibly a more forcible argument in favour of the modern opinion, than all that can be deduced from inquiries of this nature; but so long as in decaying substances the probability of ascertaining with precision the principle of the origin of fungusses, is prevented by the fitness of corrupt bodies to cause the adventitious seeds to germinate, we must consider each as an hypothesis, and determine for ourselves.

It is, however, ascertained, that fungusses produce seed which contains the properties of germination; and that vegetable corruption is suited to effect it. When we contemplate the fineness and volatility of the germs, the hypothesis will not appear unreasonable, that they are conveyed by the rains into the earth, and are absorbed by other vegetables; that with the sap they are disseminated throughout the whole body, and begin to germinate so soon as the vegetable has proceeded to corruption. Whatever, therefore, may be the appearance or situation of the fungus producing the dry rot, or from whatever substance it originates, that substance must either be in a corrupting state, or contain upon the surface the viscous exhalations of a putrescent matter. The first contains in itself the principle of the fungus, and the latter affords a proper recipient for the seeds deposited by the external air.

Fungusses confessedly result from, or are attendant on, vegetable corruption, assisted by an adequate proportion of heat and moisture.

Vegetable corruption invariably presupposes fermentation, on which I shall take leave to offer a few observations, selected from the works of authors of universal celebrity.

“ Fermentation is a state of vegetable matter, the component
“ parts of which have acquired sufficient force to produce an in-
“ testinal motion, by which the earthy saline, the oily and aqueous
“ particles therein contained, exert their several peculiar attractive
“ and repulsive powers, forming new combinations, which at first
“ change, and at length altogether destroy the texture of the
“ substance they formerly composed.”

“ Living

“ Living vegetables undergo a degree of fermentation which is
“ corrected by the vital motion preserving them from dissolution
“ which otherwise would necessarily ensue; for when the vital
“ motion ceases, the fermentation increasing and acquiring power
“ according to the concurrence of circumstances, it will cause the
“ substance to pass from state to state, proceeding onward to po-
“ sitive putrefaction.”

There are two things essential towards creating and sup-
porting the intestinal motion, namely, heat and humidity; for
without heat, the fixed air, which is supposed to be the co-
hesive principle of all bodies, cannot be so rarefied as to resume
its elasticity; and without humidity there can be no intestinal
motion.

Having, Sir, considered the origin of fungusses so far as
appears to be necessary towards acquiring a knowledge of the dis-
ease which is termed the dry rot, I shall conclude this part of
the subject by observing, that they are sometimes propagated by
root. This was originally suggested by Buxbaum, and requires
but little confirmation, since every day evinces the truth of it in the
subterraneous existence of the fungus, which is found to occasion
the decomposition of timber, so long lamented, and so little un-
derstood.

Your well-known attachment to science will make it unne-
cessary that I should apologize for intruding so long an investi-
gation

gation on your indulgence. I have been further induced to this for the purpose of more readily conveying my ideas of the fungus in the course of future observations on the dry rot.

I am, SIR,

Most respectfully,

Your obedient Servant.

LETTER

LETTER II.

ON THE APPEARANCES OF THE FUNGUS OCCASIONING THE
DRY ROT.

SIR,

HAVING in my former letter made some observations on the origin of fungusses, I now propose to consider the appearances of that to which we attribute the dry rot.

This fungus is of various appearances, which differ according to the situation in which it exists. In the earth it is fibrous and perfectly white, ramifying in every direction in the form of roots. Passing through substances from the external surface, it somewhat differs from that form; here it is more ramous, separating into innumerable small branches.

The fungus protruded in a very damp situation is fibrous, and of moderate thickness, feels fleshy, and contains under its surface a considerable quantity of water. From the spot whence it arises it extends equally around, wholly covering the area of a circle. This form I apprehend would continue in whatever situation it might vegetate, if the air had no motion, and every part of the substance

on which it grew were equally supplied with a matter proper to encourage the expansion. The surface of this fungus is pursed, and of various colours; the centre is of a dusky brown, mixed with green, graduating into a red, which degenerates into yellow, and terminates in white.

From the slow progress it makes in this situation, it appears that excessive damps are inimical to the fungus; for its growth is more rapid in proportion as the situation is less damp, until arrived at that certain degree of moisture which is suited both to its production and vegetation. When further extended to dry situations, its effects are considerably more destructive to the timber on which it subsists: here it is very fibrous, and in part is covered with a light brown membrane, perfectly soft and smooth. It is often of much greater magnitude, projecting from the timber in a white spongy excrescence, on the surfaces of which a profuse humidity is frequently observed; at other times it consists only of a fibrous and thin-coated web, spreading irregularly on the surface of the wood. Excrescences of a fungiform appearance are often protruded amidst those already described, and are evidences of a very corrupt matter peculiar to the spots whence they spring. According to the situation and matter in which they are produced, they are dry and tough, or wet, soft, and fleshy, sometimes arising in several fungiforms, each above the other, without any distinction of stem; and when the matter is differently corrupted, it not unfrequently generates the small acrid mushroom.

Under these various appearances the fungus spreads itself on the surface of the timber, and becomes attached by innumerable small, and almost imperceptible fibres or tubes, by which it imbibes the stamina,
and

and occasions the decomposition of the wood: the branches will insinuate themselves through walls of very considerable thickness, and communicate the disease to the opposite side. On opening the bricks of walls which have appeared perfectly sound, the vegetable has been discovered passing through them in fibrous roots; and, from this subtle disposition, has usually been discovered before the substantial parts have been so far decayed as to endanger the edifice.

From whatever substance this vegetable springs, when once attached to the wood, it rapidly spreads around: each ramification, no longer dependant on the stem for sustenance, takes fresh hold, and supplies itself with nourishment until the whole of the part it occupies is entirely decomposed. Before this vegetable has time to destroy the girders and other principal timbers, it usually penetrates behind the skirtings, dadoes, and wainscotings, and is known to those acquainted with its effects, by drawing inward the edges of the boards, and by splitting them, both horizontally and vertically. When the fungus is taken off, they exhibit an appearance similar, both in back and front, to wood which is considerably charred: a light pressure with the hand will break them asunder, even though affected with the rot but a short time; and on taking down the wainscot, the fibrous and thin-coated fungus will, generally, be seen closely attached to the decaying wood.

I apprehend, from the similarity of effects produced, that the fungus, like the mistletoe, may properly be termed ^{aceticæ} ~~paricidal~~ ^(parasitical), as each eventually destroys the parent stock whence it derives its generation and support.

It is worthy of observation, that timber of moderate length will rapidly proceed to decay throughout the whole body, even though the ends only are occupied by the fungus, the matter congenial to its growth affording a more plentiful supply, by passing along the capillary tubes with greater facility than when educed from its natural course: hence the fungus becomes larger and more destructive.

In an experiment on the effects of this vegetable, I formed several chasms on the side of a piece of timber by cutting the space of a finger's length, the whole width, and half the depth of the wood, and at about two feet asunder. This timber I exposed to the fungus; the whole became speedily covered with it, and the side on which the chasms were formed decayed; whereas the side on which there were no chasms was scarcely affected by it. From this circumstance, we frequently find that girders and other timbers, whose ends are placed in walls, become decayed for a considerable distance from the extremities, whilst the cause remains secreted within the brickwork: thus buildings are endangered, and accidents have happened from this destructive disease, while the inhabitants have reposed in confident security.

Timber so decayed, is usually penetrated by innumerable fibres of the fungus, through the minutest separations of the texture; and it is so insinuating in its nature, and conformable in varieties of shape to that which it is about to destroy, that it passes a considerable distance into the pores, still pursuing the healthful qualities of the wood, until the whole is destroyed; or, perhaps, the substance only decayed; while the superficies remains a mere shell, disguising
the

the internal rottenness, as may be particularly seen in parts of the timber which form several bridges in this kingdom.

Here, Sir, I shall conclude these observations on the appearance of the fungus, as it will be necessary to consider it hereafter in practical remarks on its local situation; only adding, that, from the variety of appearances which this vegetable exhibits, it is not extraordinary that persons unacquainted with the dry rot should suspect that its name is derived from the situation in which they suppose it originates; and therefore when they have found it in damp places, have concluded it harmless, and neglected any attempt towards the eradication, until a rapid and destructive progress has marked its character.

I am, SIR,

Yours, &c. &c.

LETTER

LETTER III.

ON THE CAUSES OF THE DRY ROT.

S I R,

IT is a truth generally confessed, that inquiries merely theoretical, are of little importance compared with those formed in the course of practice : I therefore submit to you the following observations, derived from practical experiments, which various opportunities of witnessing this destructive disease have afforded.

The dry rot may be divided into five distinct classes, differing from each other according to their local situation, and the fungus of several descriptions. One of these is generated in the earth, one in the walls of buildings, a third is produced in the timber itself, and the fourth and fifth by causes which I shall leave to the last consideration.

OF

OF THE FUNGUS CAUSING THE DRY ROT, AS GENERATED IN THE EARTH.

A FUNGUS producing the dry rot in timber is found in the earth : it is a white and fibrous substance, very commonly attached to the roots of trees : the banks of hedges are also sometimes replete with it. In light ground, above argillaceous earths, the fungus is often discovered, and may be traced to a green feculent matter, separating the clay to a considerable depth. This slime is probably the finer parts of vegetables, separated by rain, and deposited by filtration in the fissures of the clay ; and this possibly contains innumerable germs of the fungus, secreted by the same causes from their natural or artificial attachments, and may afford a suitable matter for their germination, which actually occurs at the part which is nearest to the surface of the earth.

It is observed by Pliny, that fungusses originate in a slimy mud, and in the humours of the earth that are in a corrupting state : such a vegetable and corrupting matter he possibly alludes to as that noticed above ; for it is ascertained that portions of earth which contain the greatest quantity of putrid humour, are proportionately the most productive of the fungus.

In digging cellars, or for foundations in argillaceous soils, if the ground is not supported, it will sometimes, and particularly in wet seasons, slide in upon the work ; and in clay possessing the slimy basis of the fungus, the place of separation usually displays what appears to have been an inconsiderable fissure, filled up by vegetable slime. If this clay be properly exposed to corruption, the slime

will shortly protrude a fungus, which will cover the clay with a spongy excrescence, and the smallest fissure will be penetrated with a fibrous root, similar to that I have already described.

This fungus, when attached to timber, produces the decomposition termed the dry rot. Hence it appears that we frequently build on spots of ground which contain the fundamental principle of the disease; and thus we are sometimes foiled in our endeavours to destroy the fungus by the admission of air. Instead of effecting so desirable an end, it is evident, that, in this cause of the dry rot, the disease may be encouraged by the application of air as a remedy.

Many are the causes which combine to produce a corruption in the earth generative of the dry rot; and from the vegetation of the germs of fungusses at a considerable depth beneath the surface of the earth, it is manifest that a small portion of the air only is necessary to their germination, whether they arise in fungiforms, or become ramous.

But the disposition of vegetable matter introduced into the earth toward corruption, thence admitting the germination of the seeds, is not the only cause of the production of fungusses in this situation. It was originally suggested by Buxbaum, that they are sometimes propagated by root, and effects have corroborated his testimony in the production of the dry rot by earth removed from hedge-rows and other soils near decaying trees, to situations calculated to encourage the vegetation of the fungus contained in them.

The original production of such fungus I shall consider in its particular place; here observing only, that ramous fungusses gene-

rated within the earth, and removed to congenial situations, are equally productive of the dry rot when attached to timber. The following experiments on the productive properties of each may possibly elucidate the subject:

EXPERIMENT.

A considerable portion of the surface of that clay to which the feculent matter was attached, being placed in a situation suited to encourage the germination of the seed of the fungus (which I conjectured this matter might contain), and an equal quantity of clay unaffected by such matter being similarly situated, the first speedily became covered by a thick fungus, spreading itself to, and decomposing, a piece of wood purposely placed near it; whereas the latter exhibited no appearance of the fungus.

Previous to this experiment I had occasion to remove a floor that was decayed by the dry rot; the cause of which appeared to have originated in a quantity of clay placed under it for the purpose of elevating the ground-floor. This had been loosely thrown in; and the body of the clay becoming dry, a proper nutriment not being continued to the fungus, it had died away; but the part which had reached the floor had increased in vigour, and destroyed the wood. This observation induced me to suffer the clay, now covered with the fungus, to become dry. The vegetable soon decayed, and exhibited the same appearance with that already noticed. Various corruptions of the earth, situated in the same manner, have produced, on experiment, similar effects.

EXPERIMENT.

A quantity of light earth collected from about decaying trees, and containing the fibrous roots of the fungus, which, though not clearly discernible, could be distinctly recognised by the similarity of scent with specimens before mentioned, on experiment, produced the fungus occasioning the dry rot; while similar earth which contained no root, was wholly unproductive.

OF THE FUNGUS WHICH ISSUES FROM THE BRICK-WORK OF BUILDINGS.

The fungus which proceeds from the joints of walls, and particularly from those of subterraneous buildings, has also the property of decomposing timber.

As the fungus may, without difficulty, be traced to the spaces between the bricks, and sometimes found penetrating the bricks themselves, it is not extraordinary that many opinions have been formed on the cause of its vegetation.

It is a very common practice in modern buildings, when other sand cannot conveniently be provided, to use the refuse collected from public roads, as a substitute in the composition of our cement for walls. In consequence of the continual traffic upon them, the sand is mixed with a considerable quantity of loamy earth

earth and dung ; this being compounded with a small proportion of lime, and deposited in a humid and warm situation, necessarily admits and assists the vegetation of the seeds contained within it, or the innumerable roots which are distributed in every part of a mound of road sand, when collected moist, and exposed to the sun's rays.

The fungus of the wall does not, however, present itself until the exudation of that moisture with which the cement is composed ; it will then, according to the suitableness of the place in which it is deposited, vegetate, and assume a flat, corrugated, or a spongy substance, the roots of which may be traced to a considerable distance in the wall. Fungiforms are also found to issue from the joints of brick-work. The sand collected at the bottom of hills is usually most productive of the fungus of the wall, probably in consequence of teams being suffered to rest in such situations. When we observe the quantity of loamy earth and dung which is collected with the sand, and the innumerable fungusses ascribable to one horseball ; when we estimate the possibility of fungusses springing from walls in proportion to the number of germs implanted in them, the generation of the dry rot from this part of the edifice no longer remains mysterious ; particularly when the germs are so well exposed to vegetation, as we find they frequently are in subterraneous buildings.

It was an observation, if not of the ancients, of the oldest of the moderns who have treated of buildings (Leone Baptista Alberti), that no mortar whatever should be composed with sand, unless previously washed, to separate the loamy particles ; as, he continues to observe, it will generate fungusses.

This wholesome advice is too much neglected, or too little understood by some modern builders, who are astonished at the abundant produce of a disease, the cause of which they have ignorantly planted.

EXPERIMENT.

A portion of road sand, taken from the internal part of a large mound which had been heaped for the purpose of building, and which contained small roots, obvious only to the microscope, was deposited in a situation calculated to vegetate fungusses. In a short time a spongy vegetation began, the destructive effect of which was more rapid than I ever observed from a fungus attributed to any other cause; and the minute roots were soon increased to several ramifications: these obviously pervaded the whole mass of sand, each root forming the basis of a separate fungus. On every repetition of the experiment the same effects occurred; the vegetable differing only in appearance and quantity, in proportion as the situation was more or less supplied with heat and moisture. The same sand being washed, in order to separate the loamy particles and fungous roots, was placed near the above, and remained wholly unproductive.

I am, SIR,

Yours, &c. &c.

LETTER

LETTER IV.

OF THE FUNGUS CAUSING THE DRY ROT AS PRODUCED IN
TIMBER.

SIR,

THE corruption attendant on fermentation throughout the vegetable world, thence allowing the germination of fungusses, admits of no exception with regard to unseasoned timber, when made use of in the erection of our edifices. Much speculation has arisen on the causes of the fungus produced by this innate principle of corruption; but as it will be of no avail to consider the various opinions formed on this subject, I shall proceed to restate an hypothesis, which may be considered as reasonable when we estimate the number, minuteness, volatility, and durability of the seeds of those fungusses which are found to occasion the decomposition of timber, namely—

That the germs may be conveyed into the earth by the rains, and thence absorbed with the sap into the bodies of trees and other vegetables; and when the putrescence attendant on their decay has prepared a suitable fluid for the germination of the seeds, that they produce fungusses.

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On examining timber, the decay of which has been facilitated by the absorbent qualities of the fungus extending over its surface, and which has been originally produced from the corrupt humours of the tree, I have found innumerable minute fungusses which have germinated in the body of the wood; and the size of them has been invariably proportioned to the distance of their situations from the exterior of the timber, near which they are easily perceivable, but become less as they are more distant from it.

That these seeds are germinated by the sap, however they may have been insinuated into the body of the tree, is conformable to the opinion of Pliny, who says, that fungusses are produced by sap. The extraordinary fungusses which are frequently found on decaying trees might have given rise to this observation, which has also been admitted by modern naturalists.

The roots of decayed trees lying even with the surface of the ground, speedily produce fungusses, which will grow to a considerable magnitude.—A clay soil is a reservoir for rain, and trees which grow upon it usually abound in sap: when they contain a superfluity the tree is diseased, and endeavours to throw it off; the weaker parts separate, and form fissures, through which the sap is discharged. In pollards and other trees which have lost their branches by not having a sufficiency of leaves to employ the sap, the discharge is much greater than in such as are more perfect. About these are found various fungusses, which, doubtless, have their origin in the corruption of the sap, and grow according to the supply of nourishment they receive, which is often great, and of consequence the magnitude of the fungus is proportionate: these
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are produced by, and exist upon, the corrupted nature of the tree. If the tree be cut down, and placed in a shaded situation, covered from the free circulation of the external air, the fungus will yet increase ; and when no longer supplied with sap, it will exist upon the moisture, and occasion a decomposition of the parts around it similar to the dry rot.

When timber containing this redundancy of sap is deposited in a building immediately on being felled, it is reasonable to expect that a corruption of its humours will ensue, and that the fungus will be generated on its surface. This consequence so often occurs, that it is a matter of some astonishment, that the causes of the dry rot from this particular, have been so long considered as mysterious.

The fungus generated at the roots of trees within the earth, is probably dependant on similar causes to that which is effected on the superior parts. The redundant sap may possibly discharge itself, and corrupt at the roots in the same manner as from the trunk, admitting the germination of the seeds contained within it : and as whatever vegetates within the earth partakes of the nature of roots, the appearance of the fungus in that situation may possibly be accounted for.

From the foregoing observations it appears that, in some cases, fungusses are not the primitive cause of the decay of timber ; but that to the corruption of its humours may be attributed the origin of the fungus when produced in the timber itself, independent of extraneous putrefaction : thus fungusses in some timber are not the disease, but the effects of it ; and thus a small portion of unseasoned timber, when placed in a building, may generate the dry
rot,

rot, and disseminate its baneful effects throughout the edifice into which it may have been unwarily introduced.

Amidst these inquiries into the causes of the dry rot, I have been led to consider the ultimate purpose for which Nature has implanted peculiar properties in the seeds of fungusses, and the wonderful profusion with which they are universally disseminated.

Fungusses pervade vegetable corruption, absorb those parts which are rendered fluid by putrescence, and prevent its arising in noxious and baneful vapours in greater quantities than Nature has provided the means for reduction into common air. The greater part of fungusses are only discovered in situations where this desirable purpose is not otherwise effected: if therefore it appear, that every vegetable which produces fungusses upon its decay should be supplied with seed previous to its fermentation (for it is an extravagant hypothesis, that all the seeds are distributed adventitiously at the moment of corruption); their minuteness must be such as to allow of volatility: and as some vegetables are capable of preserving the principle of fermentation for a very extensive period, so the seeds of fungusses should possess very extraordinary properties for duration; and these we know they do possess in an eminent degree.

The prejudicial consequences of foetid vapours arising from vegetable putrefaction are so well known, and so much lamented, that little need be said to obtain admiration of the abundant supply of means by which, in situations not calculated to admit of the progressive translation of vegetables into others more obviously suited to the support of animal life, the baneful particles are rendered harmless.

The decomposition necessary in the progressive course of nature, is also facilitated by the property of fungusses: while the corrupt fluid is arrested, the remaining particles of the substance are separated, and prepared for the work of reproduction. Fungusses vegetated in damp places, are capable of affording extraordinary fertility to the spots of earth to which they may be applied; and, although the quantity of them do not allow of application by us to general purposes, it is continually done by Nature, and much more universally.

The striking analogy between vegetable corruption and animal putrescence affords ample scope for animadversion; I shall, however, merely indulge in observing, that, as a considerable portion of noxious animal fluid is prevented from passing into the air from corrupt flesh, by myriads of animals generated within it, so vegetable corruption is absorbed by the fungusses generated upon its surface in incalculable profusion.

I am, SIR,

Yours, &c. &c.

LETTER V.

OTHER CAUSES OF THE DRY ROT CONSIDERED.

SIR,

HAVING seen that fungusses are propagated from the earth on which we build, and from two materials with which buildings are composed, I proceed to other causes of the dry rot.

It is not uncommon for a building to be affected with this disease, the cause of which can be attributed to neither of the foregoing materials, but to a collection of putrescent matter adhering to the timber, caused by an adjacent vegetable corruption, and to a natural disposition in the timber to decay, assisted by the situation in which it is placed.—When the parts of an edifice are so formed that a successive admission of pure air cannot take place, the vegetable exhalations, from corrupted matter in the earth, will collect upon the surface of the timber, affording a proper recipient for the seeds of fungusses, which speedily become attached to, and find nourishment within it.

Cellars which contain quantities of some liquors are well known to possess a deleterious atmosphere, caused by the fermentation of the fluids: and if a free circulation of air be not admitted, the vapour will collect in various parts, on which innumerable fungoides, or a mouldiness, may be observed. The fermentation of vegetables, in spaces incomparably more confined, may therefore be expected to afford a greater quantity of matter suited to the purpose of germinating fungusses, by which their infant state may be supported until they acquire strength to penetrate the timber, and absorb its moisture.

Many sources might be adduced giving birth to matter adequate to the propagation of fungusses; but as all are derived from the same cause, namely, vegetable corruption, it will be unnecessary to dwell longer upon them.

There is yet a decomposition of timber termed the dry rot, which is sometimes effected without any appearance of mouldiness or other fungus, except in the germination of some seeds, which are usually found in the substance of the decayed wood: a fungus, however, has been produced on the surface of this timber; but I have observed, that, notwithstanding they are swept off so soon after they are germinated as they become visible, the timber will proceed to decay by its fermentative principle of dissolution, exhibiting a similar appearance of decomposition with that effected by the fungus.

This effect does not happen to timber where the particles have become fixed; such timber will not produce the fungus, neither does

it contain upon its surface a proper recipient for the seeds supported in the air.

Count Rumford, in an ingenious investigation of the propagation of heat in fluids, has demonstrated a principle by which Nature has provided a mean of securing trees from injury during severe frosts, by a congelation of their sap, which again recovers its action in the temperature of spring, exhibiting a system of vegetable economy, long obscured by the idea that the particles of fluids were capable of transmitting heat to each other, and by erroneous opinions on the falling of the sap. I gladly anticipate the beneficial result of the inquiry towards the general preservation of timber; and from this system I shall endeavour to account for its intestinal decay.

A living tree is formed with very perfect capillary tubes, the forms of which are exquisitely calculated to raise the moisture from the roots; this moisture becomes viscous on the approach of winter, and preserves the tree from that injury which must otherwise necessarily take place from the inclemency of the season. To the unproductive condition of the tree at this time the eye is well accustomed; and that it arises from the inactivity of the fluids, is generally acknowledged. On the approach of spring it recovers its fluidity, and the sap performs its accustomed functions.

In contemplating this economy of vegetation, after an acquaintance with the experiments of Count Rumford on the propagation of heat in fluids, the mind is forcibly impressed with the idea that the sap has acquired two motions; one of which is performed

formed by its passage up the capillary tubes, and the other is an individual motion of the particles of the fluid excited by the approach of heat, as elucidated by the Count's experiments.

Timber is usually felled when the sap is in the viscous state. If at this time the timber be subjected to heat and moisture in any building, the sap will acquire its second motion, and consequently its fluidity—so far the individual motion of each particle of the fluid necessarily occurs, and affords a suitable matter to admit of the intestinal or fermentative motion excited by the heat of the situation, which heat changes the nature of the fixed air from a concrete body into that of an elastic fluid. As the firmness of the timber is wholly dependant on the restraint of this air, the escape of it, which under this circumstance inevitably takes place, may be well expected to cause that separation of the particles to which is given the appellation of the dry rot.

Having thus far endeavoured to shew that the causes of the dry rot are ascribable to the production of fungusses from some suitable matter in the earth, the timber, the brick-work, and also by the corruption of vegetable substances; and having considered the means by which timber becomes decomposed by a simple effect of nature, it may not be irrelevant to reflect on the possibility of the disease becoming a compound one.

When the essential causes of vegetable fermentation afforded by the injudicious construction of a building, are combined with the corrupt qualities of the earth on which we build, the propagative principle of the fungus deposited in the walls, and the tendency of the timber itself to corrupt and decay, it must appear that the
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dry rot may be produced by each of these causes at the same period. Every attempt, therefore, to eradicate the disease must be futile, unless the productive properties of each are separately counteracted.

This complication of the disease has occasioned many of those difficulties which have hitherto attended the cure of the dry rot; as very few of those persons who have most attended to the examination of its causes, have traced it to either of the foregoing sources; or, if in one of them the application of a remedy has succeeded, upon another trial it has failed, in consequence of the production of the rot from a dissimilar cause, or in the combination of the several causes at one time.

On a review, Sir, of these observations, it appears that vegetable corruption is suitable to receive and germinate the seeds of fungusses, and that such fungusses are capable of absorbing the medullary particles of the wood, thereby wholly decomposing it; and that the timber itself, when deposited in confined, warm, and moist situations, before the intestinal motion of the particles is suspended, necessarily undergoes the fermentation which is attendant on vegetables, by which Nature effects the purposes of reproduction, and is consequently decomposed with similar appearances to that effected by the fungus.

Here, Sir, it may be necessary to state more summarily the causes of the dry rot. This I do with a degree of confidence, the result of investigation, corroborated by experiment; and which

I trust

I trust the foregoing observations have sufficiently illustrated, namely—

First. *A fungus capable of absorbing, and existing upon the qualities of the wood by which the particles are combined; germinated by the humours of the tree, or communicated by an adjacent vegetable corruption.*

Second. *An internal and natural tendency to decomposition in unseasoned timber, encouraged by the warm and humid situation in which it is placed.*

I am, SIR,

Yours, &c. &c.

LETTER

LETTER VI.

SOME OBSERVATIONS ON THE CURE OF THE DRY ROT, AND ON
THE ADMISSION OF AIR INTO THE PARTS OF BUILDINGS
AFFECTED BY THAT DISEASE.

SIR,

THE uncertainty of success which has attended every attempt to cure the dry rot in timber, even where circumstances have favoured the application resorted to, might well preclude hope, when the situation, the ground, and the materials of which buildings are composed, have conspired with the construction of the edifice to promote the evil: but, notwithstanding this, the devastative nature of the dry rot, and the obscurity in which the causes of it have been hidden, it is expected that a nostrum will be discovered, which, upon application, shall exterminate the whole disease.

The foregoing attempt to develop the various causes of the dry rot will, I trust, expose the futility of this hope; the sanguine principle of which is only calculated to retard the adoption of effective remedies.

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When the fungus originates in the earth, the brick-work, or the timber of a building, the disease may be eradicated by taking out the materials, and by inducting such as will not be capable of affording the means of vegetation ; and when the disease is caused by putrescent vapour alone, its return may be prevented by rendering the situation perfectly dry and pure. In every circumstance of the disease it is of importance that the latter should be effected, by constructing the edifice in a manner that will not admit of its acquiring heat, or accumulating vapour, carefully introducing as auxiliaries such chymicals as may tend to effect the anti-vegetation. I am, however, persuaded, that the dry rot is seldom of this simple nature ; and that it is produced by such varieties of combination that no remedy can be applied with confidence, unless it is scientifically formed upon the rationale of the several causes.

The irregular surfaces, and the remote parts of buildings, so well conceal and fortify the seeds of the disease against the effects of external application, and they are so incalculable in number, so impalpably minute, and so volatile and durable in their nature, that it is in vain to seek the cure in attempts to extirpate or destroy them ; and the small and penetrative fibres are equally obnoxious to such remedies. It is, therefore, only from a dereliction of the prevailing hopes of cure giving birth to inefficacious nostrums, that we may expect the mind will be at liberty to cogitate the means by which we may prevent a matter from being formed, which might prove efficient to the vegetation of the germs ; and, if formed, either to remove it, or prevent its affording to the seeds the means of germination.

On the judicious and scientific mode adopted to effect these purposes, founded on the existing circumstances, will wholly depend the eradication of the disease, and the safety of the building.

The importance, Sir, of air, towards the cure of the disease will, I trust, be a sufficient apology for the following observations.

ON THE ADMISSION OF AIR INTO THE PARTS OF BUILDINGS AFFECTED BY THE DRY ROT.

The various attempts of a century to cure the dry rot having proved unsuccessful, the disease not being sufficiently ascertained to admit of scientific applications, the many endeavours to discover its causes were considered as hopeless, until the admission of air as a remedy was sometimes attended with beneficial effects. Those who had failed in their former attempts to eradicate the disease by other principles, naturally resorted to this application, as the only possible means of cure; and contenting themselves with the first solution of the mystery which presented itself, they concluded that, as pure air acted as a preventive, or sometimes destroyed the fungus, the disease must necessarily be caused by stagnant air alone.

If in the former observation, Sir, this hypothesis on the origin of the dry rot in timber is not refuted, the accurate investigations of Spallanzani will sufficiently expose the fallacy of it: his experiments have proved that fungusses have the same relation with air as other plants, as none will live without a supply of fresh
air,

air, although he continues to observe an equal quantity is not necessary to all. That stagnant air is fatal to vegetable life, is an ancient opinion, now universally admitted by modern naturalists: we may therefore conclude with confidence, that stagnant air is fatal to fungusses; consequently it cannot be the cause of that fungus which sometimes occasions the dry rot in timber.

Since the admission of air has been long considered the only means of destroying the fungus, and as this has frequently proved ineffectual, it will be necessary to ascertain in what instances air has been beneficially administered, and also from what cause the evil has been increased by the introduction of air into diseased buildings.

If timber affected by the fungus rot in a small degree, be taken from a very confined situation, and placed in one to which more air is admitted, we find the fungus will increase: if a greater portion of air be supplied, the fungus will yet increase, and continue so to do in proportion to the quantity admitted, until it has become too powerful for the existence of the fungus, as a proper supply of nourishment cannot be so rapidly obtained from the decaying wood, as the dry air requires in moisture from the plant. If exposed to the open air and the rays of the sun, the fungus withers in a short period: hence it appears, that pure or dry air, freely admitted, exhales much more from the fungus than the plant can possibly absorb from the diseased wood; and, in proportion as this exhausting principle becomes more powerful than the moisture of the timber can supply to the fungus, so much the sooner the vegetable will decay; but should the air secrete less moisture from the fungus than the timber affords to its vegetation,

the air will then increase the disease, and draw into fuller growth the fungus it has not sufficiently the power to destroy.

We may then observe, that, if dry air be properly admitted in a quantity adequate to cause that absorption, it will necessarily exhaust and destroy the fungus; but it should be considered whether at the same time the disease may not be conveyed into other parts of the building by the insinuating property of the air, in which innumerable seeds of the plantulæ are supported, after being separated from the fungus over which it has passed, while it is scarcely possible to admit a sufficient quantity of air calculated to destroy the fungus. Air, in passing through damp, will partake of their humidity; it therefore soon becomes inadequate to the salutary task for which it is designed. Owing to this circumstance, air has been frequently admitted into the affected parts of a building without any ultimate success:—too often, instead of injuring the fungus, it has considerably assisted its vegetation, and infected with the disease other parts of the building which would otherwise, probably, have remained without injury.

The antidote to the vegetable dry rot proceeding from the earth, the brick-work, and the timber, must not always therefore be sought in common air. With regard to the fungus produced on the timber by putrescent vapour, the admission of air may more reasonably be supposed to succeed, if administered in the early stages of the disease, as the fungus does not so speedily penetrate the wood, and absorb the moisture in such large quantities, as when generated from other causes; and when the vapour is dried up, there is no longer a suitable recipient for the germs that are scattered

tered by the circulating air. The timber which is in a state of decomposition by an intestinal decay, is little affected by the application of air, as this cannot penetrate the surrounding spongy rottenness which generally forms the exterior of such timber, and protects the action which the humid particles have acquired in the exterior: as the extent and progress of the disease is therefore necessarily concealed, it is difficult to ascertain correctly the effect produced by the admission of dry air.

The application of heat to the diseased timber, as might be well expected, is similar in its effects to that of air, with the exception only, that, when admitted, it either occasions a more rapid dissemination of the disease, or destroys it with greater facility.

Notwithstanding the danger of admitting air to the interior of a building which is affected by the fungus, it frequently becomes necessary to remove the impure air contained in the vacuities between floors, or cellars, when sufficient apertures are not formed; not more for the purpose of destroying the rot, than to prevent a noxious and prejudicial effluvium from passing into the inhabited parts of the building, the unwholsomeness of which is not unfrequently attributed to the fungus, when found in such situations.

Under these circumstances of necessity and danger, it will require considerable skill to effect the purpose without increasing the disease; and it is indispensably necessary, that every person who takes upon him to admit air as a remedy to this evil, should previously estimate the destructive consequences which may result,

and ascertain if it will not be more injurious than beneficial to the building ; for the application of it to the vegetable rot is similar in its effects to that of air when applied to fire, which will either extinguish or invigorate its powers. From too little consideration in this practice, many noble mansions have been destroyed, and much useless expenditure incurred in others, both which would have been prevented by a little attention to the corrective properties of air, and some experience in the real nature and extent of the disease.

I am, SIR,

Yours, &c. &c.

THE END.